Integrated Modelling of ASDEX Upgrade nitrogen seeded discharges

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One of the most crucial and challenging issues of the fusion research is the development of an ITER scenario which satisfies simultaneously the requirement of sufficiently high power amplification with the needs for sustainable power exhaust. Independent of the plasma facing materials in ITER, impurity seeding will become an inevitable element of the operation to protect the divertor from excessive heat loads.

In view of possible realistic predictions for ITER-relevant scenarios with impurity seeding, JET discharges with nitrogen injection have been successfully simulated in recent years using the self-consistent transport code COREDIV [1]. In particular the code has been benchmarked against the nitrogen seeded type III ELMy H-mode discharges on JET [1, 2] and neon seeded JET AT scenarious [3] proving its capability of reproducing the main features of JET seeded plasmas like electron temperature and density profiles, the total radiated power, and the effective charge, Z_{eff}. However, the applicability of the model to a full tungsten environment has not been tested, so far.

This paper describes integrated numerical modelling for the first time applied to ASDEX Upgrade (AUG) discharges with full tungsten wall using the COREDIV code. In the AUG experiments, a very beneficial behaviour in terms of reduced power loads, moderate impurity concentrations and increased confinement has been found in N_2 seeded discharges. Radiative cooling has been applied in a large variety of plasmas ranging from improved H-Modes at intermediate density and heating power to discharges with very high heating power ($P_{aux} \approx 20$ MW) or high density and radiation fraction exploring the type-III ELM regime [4].

The paper aims at numerical simulations of AUG N_2 seeded scenarios with the COREDIV code. Since the energy balance depends strongly on the coupling between the bulk and the scrape-off layer plasma, modeling requires the transport problem to be addressed in both regions simultaneously. The COREDIV code self-consistently solves radial 1D energy and particle transport equations of plasma and impurities in the core region and 2D multifluid transport in the SOL. The model is fully self-consistent with respect to both the effects of impurities on the energy losses and the interaction between seeded and intrinsic impurities. First, in order to fix some of the code input parameters we have benchmarked the code against two AUG shots with (#25708) and without (#25353) nitrogen puffing. In the shot #25353 the "natural" tungsten radiation is relatively low(48%), and it is only slightly increased, up to 56%, with strong seeding. In agreement with the experimental observations, the seeding does not lead to significant increase of the tungsten concentration, which changes only by factor 1.6. Next the COREDIV code is used to provide insight on the plasma behaviour for different scans with plasma densities, heating powers and nitrogen puffing rates.

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